Naval Command,
Control and Ocean
Surveillance Center RDT&E Division San Diego, CA
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Analysis of Historical Oceanographic Data on a Personal Computer

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San Diego, California 92152–5001

K. E. EVANS, CAPT, USN
Commanding Officer

R. T. SHEARER
Executive Director

ADMINISTRATIVE INFORMATION

Work for this report was performed by the Advanced Systems Operations Branch (Code 742) of the Advanced Surveillance Concepts and Systems Engineering Division (Code 74) of the Naval Command, Control and Ocean Surveillance Center RDT&E Division, San Diego, California.

Released by
G. S. Sprouse, Acting Head
Advanced Systems
Operations Branch

Under authority of
M. R. Akers, Jr., Head
Advanced Surveillance Concepts
and Systems Engineering Division

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INTRODUCTION

The Master Oceanographic Observation Data Set (MOODS), maintained by the Naval Oceanographic Office (NAVOCEANO), Stennis Space Center, Mississippi, is the standard Navy database for oceanographic observations (references 1 and 2). Data contained in MOODS include observations of thermal and chemical properties of the water column from surface to bottom, the biota and currents in the water column, and the underlying sea floor as collected by oceanographic agencies worldwide. Although MOODS provides the most comprehensive collection of oceanographic data available, these data require analysis to provide insight into oceanographic processes in regions of interest to operational naval forces and Navy laboratories. Because these regions frequently change in response to world politics, the Navy must be able to examine regional ocean characteristics whenever and wherever needed. This was illustrated recently when the focus of naval operations shifted from deep water to littoral regions, revealing that little environmental information was available for the littoral regions.

This report describes Program MDS, software developed at the Naval Command, Control and Ocean Surveillance Center, RDT&E Division (NRaD), to process regional sets of expendable bathythermograph (XBT), ocean station (OSTA), and conductivity-temperature-depth (C-T-D)/salinity-temperature-depth (S-T-D) observations resident in MOODS. Input to Program MDS must be processed by one of two methods: (1) downloading the MOODS data provided by NAVOCEANO on 9-track tapes into regional files and subsequent separation by water mass using a minicomputer at NRaD, or (2) translation of data from a particular naval operation or oceanographic survey to a revised MOODS format from NAVOCEANO on diskettes.

Program MDS was programmed in PowerBasic in MS/DOS on a 386-series microcomputer with hard disk, Bernoulli drive, and math coprocessor. Data output is via a Laser Jet Series II printer and floppy diskettes.

ARCHIVED DATA

The most common sources of data for this program are regional files generated on a SUN SPARC 10 workstation (host code WAHOO) at NRaD and downloaded using the microcopy protocol (MCP). The original MOODS data have been separated into regional files for convenience (reference 3). Criteria for the construction of regional files were based on two factors: (1) natural geographic divisions such as shorelines, island chains, continental shelves, etc., and (2) the amount of data available. Regions are not constrained to rectangles, but may be downloaded into complex shapes using (1) a least-squares fit of latitude/longitude and (2) a combination of subareas using the MS/DOS COPY command. An example of a regional file is SOCAL.MBT, which contains all available XBT data for the Southern California Bight. Figures 1 through 5 provide the names and locations for MOODS data currently available on WAHOO.

The MOODS database was revised in 1993 to conform with security requirements. These data are available from NAVOCEANO Code N3211 on diskettes with individual data files. These files require preprocessing on an IBM-compatible personal computer before they can be accessed by Program MDS (reference 4). Theoretically, larger data sets could be transferred electronically using the File Transfer Protocol (FTP), but this method has not been verified. An example of data in the new MOODS format is file 260393.DOM, which contains XBT data

collected aboard the USNS *Silas Bent* (AGS 26) during Exercise SHAREM 102A. This file was renamed SHRM102A.MBT during preprocessing by Program NUMDS to show the data source and type.

Program MDS can process in-situ XBT data collected with a Sippican MK-12 Oceanographic Data Acquisition System. Reference 5 gives the procedure used to process these data into the required format.

Both the original and revised files are stored in the same format, with the type of data indicated by the file extension. The first letter of the extension, "M," denotes the source of the data (MOODS). The second and third letters represent the type of data included: "BT" for shipboard XBT data, "AX" for airborne bathythermograph (AXBT) data, "OS" for ocean station (Nansen cast or hydrocast) data, "ST" for electronic sensors (C-T-D or S-T-D data), and "SG" for XBT and AXBT data in naval message (BATHY) format. Only AXBT data and BATHY message data that have been preprocessed with Program NUMDS can be used in Program MDS.

> **Note**: Use of AXBT and BATHY message data is not recommended because of the high error rate incurred during the process of digitizing and encoding these data. An exception is AXBT data collected digitally by institutions such as NAVOCEANO and the Naval Research Laboratory (NRL). Data collected by mechanical bathythermographs are considered unacceptable because of high hysteresis associated with this system.

DRIVE ASSIGNMENT

Different computer situations (e.g., classified or unclassified data) and hardware (hard drive or Bernoulli drive) will require the use of different computer configurations. Therefore, Program MDSDRV was developed to designate and store computer drive information, with automatic retrieval by Program MDS.

DATA SECURITY

Both classified and restricted data may be included in a MOODS file. Classified data must be processed only on a secure system to ensure that the data files are not compromised. Restricted data may be either classified or unclassified; however, restricted data are politically sensitive and cannot be issued to all users. Output from Program MDS is not classified because the platform identifier and the geographic position are not included on the graphic.

Many secure systems do not allow printed output. In such cases, the output may be stored on a diskette for later printing by indicating at the beginning of the program that the data are being processed on a secure system.

PROGRAM DESCRIPTION

On initiating Program MDS, the user must indicate (1) if the computer is secure (i.e., output is to file only, with no printer capacity), (2) file name and type data, (3) plot title, and (4) period (by month, season, or all inclusive). The program can process data in three formats: (1) x-y plots of any two parameters; (2) histograms of temperature, salinity, and acoustic properties; and (3) statistics for various parameters. The three formats are described below.

PLOT PARAMETER

Ocean station and C-T-D/S-T-D data may be plotted as

(1) temperature, salinity, sigma-t (density), or sound speed versus depth;

(2) temperature versus salinity either as a scatter diagram at a specified depth or as a continuous profile over the entire depth range;

(3) sigma-t or sound speed versus temperature; or

(4) the effect of salinity on sound speed versus depth.

XBT data, using constant salinity of 35.0 parts per thousand (o/oo), where required, can be plotted for only the first of the four plots.

Figure 6 shows a typical plot of temperature versus depth using S-T-D data in the eastern Pacific Ocean. Although few profiles are available, the presence of two different water regimes is evident. Plots of sound velocity and salinity profiles in an adjacent area are shown in figures 7 and 8, respectively. Figures 9 and 10 show the difference between the different types of temperature-salinity (T-S) plots. Figure 9 shows the relationship at a specific depth; figure 10 shows the relationship over the entire depth spectrum. Both are excellent tools for diagnosing differences between water masses. Similar plots with hydrocast data are less definitive because of the lesser accuracy and sampling method associated with these systems (figure 11). However, hydrocast data are far more plentiful than C-T-D/S-T-D data and thus cannot be ignored in many regions.

Figure 12 shows the distribution of density (sigma-t) versus depth. The laws of physics require that density must increase with respect to depth if the water column is to be stable. Thus, inversions on this plot suggest that the data are questionable. While algorithms are available to adjust salinity values until stability is achieved, Program MDS does not perform this operation.

Figures 13 through 16 show the effects of salinity on related parameters. The plots in figures 15 and 16 are particularly meaningful; the dotted line down the center of each plot signifies where the profiles would be plotted if salinity were constant at 35 o/oo. Figure 15 is typical of the eastern Pacific Ocean, where relatively fresh water forms a positive halocline in the near-surface layer, so that the acoustic signals will be refracted toward the surface. The converse is true in the Mediterranean Sea, where high salinity in the near-surface layer causes downward refraction (figure 16). Variation of salinity with respect to depth is shown by offset from the line depicting 35 o/oo.

HISTOGRAMS

Histograms can be plotted for

(1) temperature and salinity at each of nine preset levels between the sea surface and 400 m;

(2) sonic layer depth, with cut-off frequency in either the near-surface layer or the strongest observed sound channel (primary or secondary); and

(3) depth or thickness of the strongest sound channel.

Output may be either a histogram or a printout of histogram computations, as shown in figure 17. Variable bin size, when used with the T-S plots discussed in the previous section, provides a valuable tool to determine water mass boundary criteria.

> **Note**: Sound channel statistics are computed for the channel having the lowest cut-off frequency. In subpolar regions, where the deep sound channel approaches the surface, Program MDS cannot reliably discern the difference between deep and secondary sound channels. This problem is mitigated by the fact that, for most tactical purposes, sonic energy travels equally well in both ducts.

STATISTICS

Statistics may be generated for (1) temperature and (if available) salinity at nine levels between the sea surface and 400 m and (2) the acoustic properties of the near-surface layer, secondary sound channel, and depth zone of maximum downward refraction. The latter parameter offers an estimate of the best depth for a submarine to avoid detection. Occurrence of zero sonic layer depth, useful secondary sound channels, multiple sound channels, and half channels is also provided. Figures 18 and 19, using C-T-D data collected for region CANNW, are typical of the statistical plots available. Figure 18 provides number, mean, standard deviation, and minimum and maximum values for each of 26 parameters; figure 19 shows the correlation between parameters. These data are particularly helpful in determining oceanic variability with respect to naval operations and laboratory evaluations.

> **Note**: Because of the considerable variability that occurs in the upper layer of the sea, statistical computations should be made for 1-month periods only.

SCREEN CAPTURE

Graphics generated by Program MDS were designed to be captured by Deluxe Paint II Enhanced, a product of Electronic Arts, Inc. The screen capture procedure allows subsequent editing and printing of graphics for briefings and publications. Although Program MDS has not been tested with other screen capture routines, the user is encouraged to experiment with available commercial programs.

REFERENCES

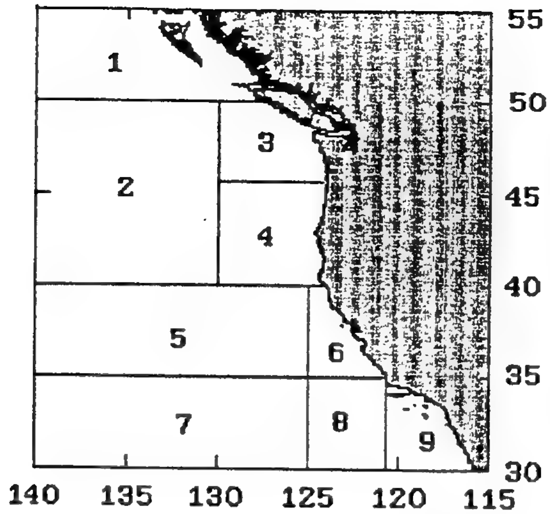
1. Bauer, R. "Functional Description: Master Oceanographic Observation Data Set (MOODS)," Compass Systems Inc., 1982.

2. Jugan, M. J. and H. Beresford. "Editing Approach for the Navy's Master Oceanographic Observation Data Set," published in *Proceedings of MTS '91, An Ocean Cooperative: Industry, Government, and Academia, vol. II,* 1992.

3. Fisher, A., Jr. "Analysis of Historical Oceanographic Data with a Microcomputer," [in preparation].

4. Fisher, A., Jr. "Downloading Environmental Data in the New MOODS Format," NRaD TD 2703, Naval Command, Control and Ocean Surveillance Center RDT&E Division, San Diego, California, September 1994.

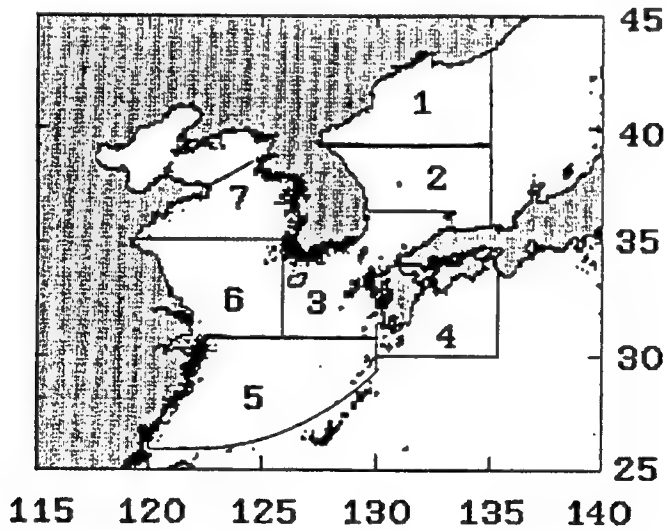
5. Fisher, A., Jr. "Data Processing Routines for the Sippican Mk-12 XBT System," NRaD TD 2626, Naval Command, Control and Ocean Surveillance Center RDT&E Division, San Diego, California, April 1994.



LEDGEND:

1 CANNW 2 EPAC1 3 ASJDF
4 PACNW 5 EPAC2 6 NOCAL
7 EPAC3 8 EPAC3A 9 SOCAL

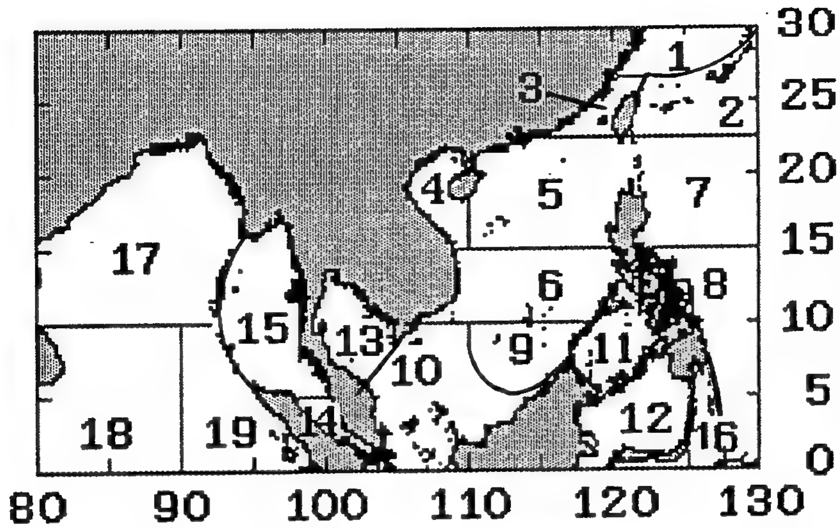
Figure 1. Regional files for the northeastern Pacific Ocean.



LEGEND:

1 NWSOJ 2 SWSOJ 3 KOREA
4 EKYU 5 ECHINA1 6 SYELLOW
7 NYELLOW

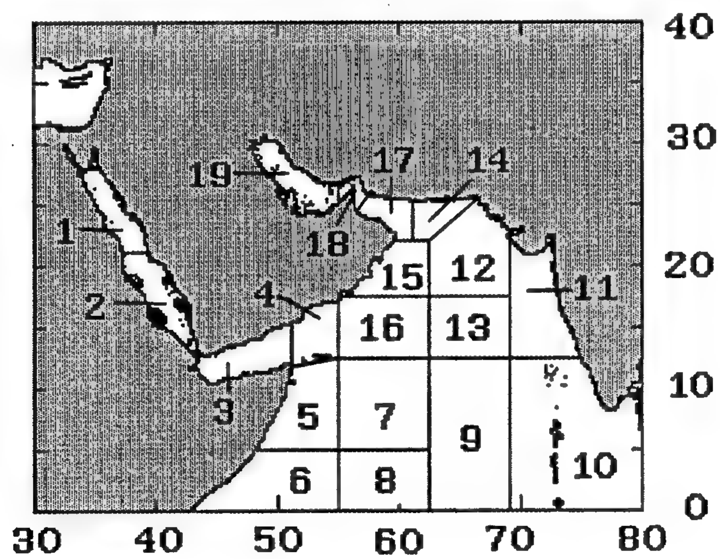
Figure 2. Regional files for the western Pacific (WESTPAC).



LEGEND:

1 ECHINA1 2 ECHINA2 3 BASHI 4 TONKN
5 SCHINA1 6 SCHINA2 7 EPHIL1 8 EPHIL2
9 SCHINA3 10 SUNDA 11 SULU 12 CELBS
13 THAI 14 MALAC 15 ANDMN 16 NMOLUC
17 NBNGL 18 SWBNGL 19 SEBNGL

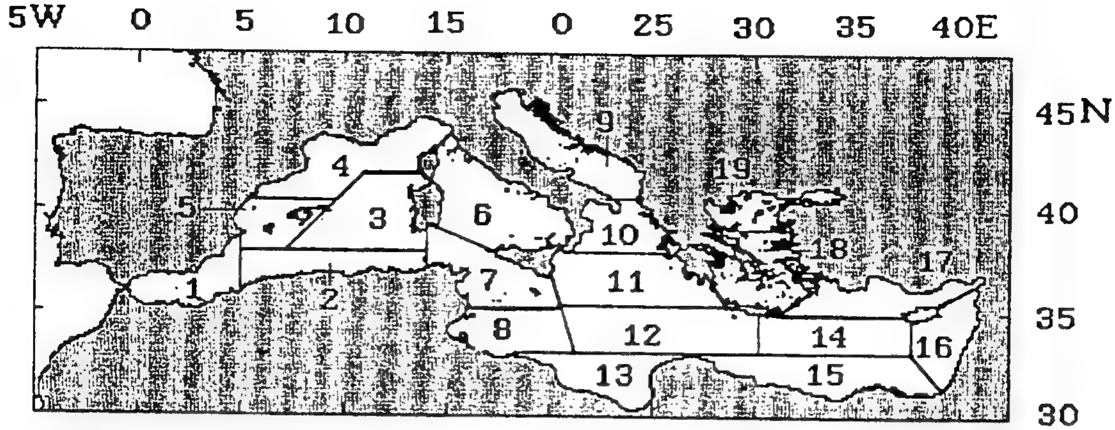
Figure 3. Regional files for Southeast Asia and the Indian Ocean.



LEGEND:

1 NRED 2 SRED 3 ADENW
4 ADENE 5 NSOMALIA 6 SSOMALIA
7 WARBN1 8 WARBN2 9 CARBN
10 EARBN 11 NEARBN 12 NCARBN1
13 NCARBN2 14 PAK 15 NWARBN1
16 NWARBN2 17 GOMAN 18 STRHOR
19 PERSNG

Figure 4. Regional files for the Arabian Sea and neighboring areas.



LEGEND:

1 ALBORAN	2 NAFRICAN	3 ALGERIAN	4 SFRANCE
5 VAL	6 TYRR	7 STRSIC	8 LIBYA
9 ADRIATIC	10 IONIAN1	11 IONIAN2	12 IONIAN3
13 SIDRA	14 EMED	15 SEMED	16 LEVANT
17 NEMED	18 AEGNS	19 AEGNN	

Figure 5. Regional files for the Mediterranean Sea.

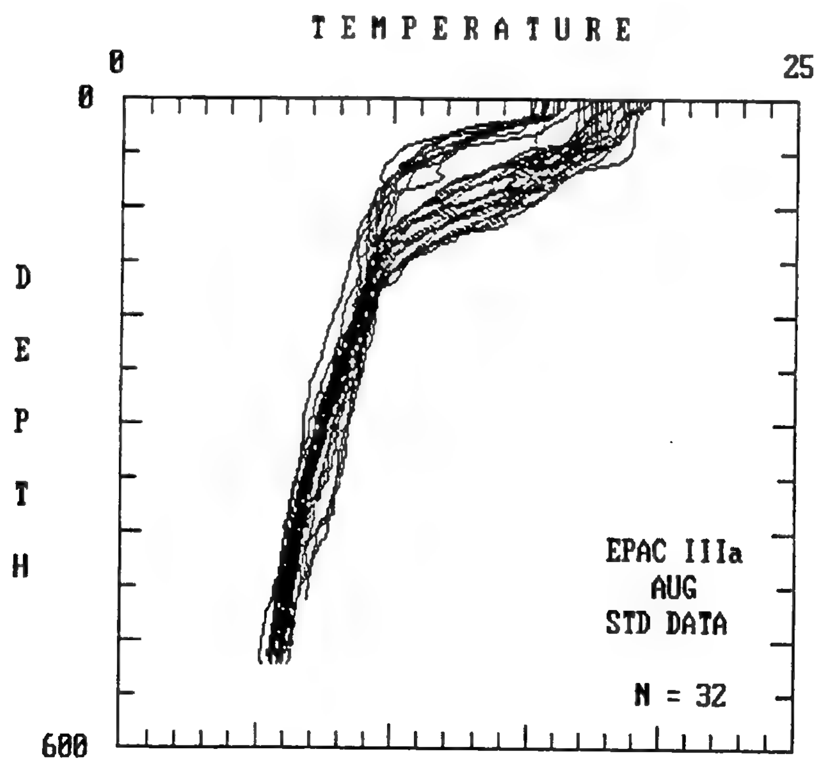


Figure 6. Plot of temperature versus depth.

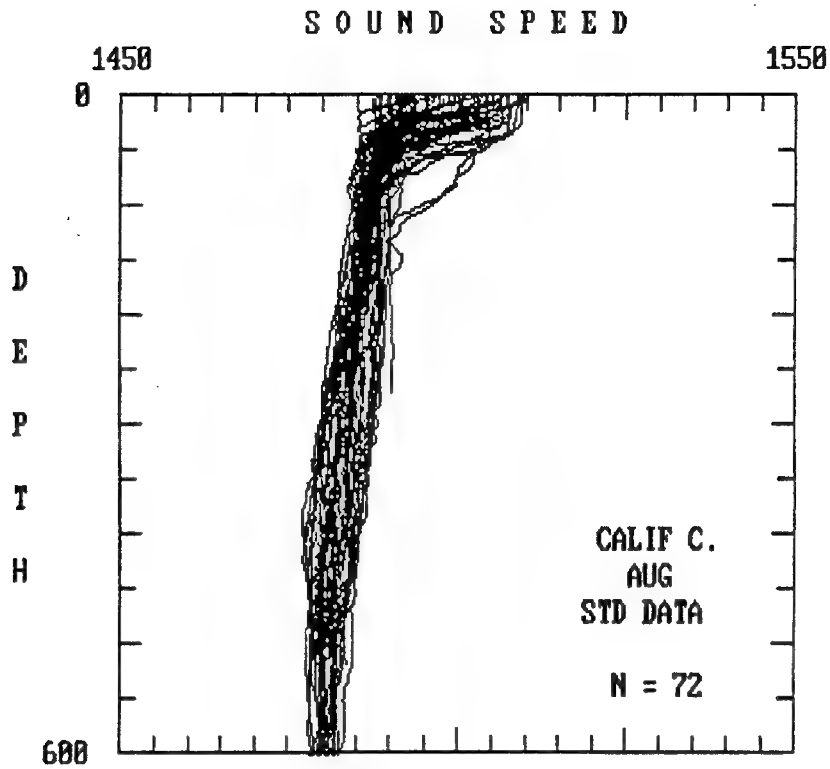


Figure 7. Plot of sound speed versus depth.

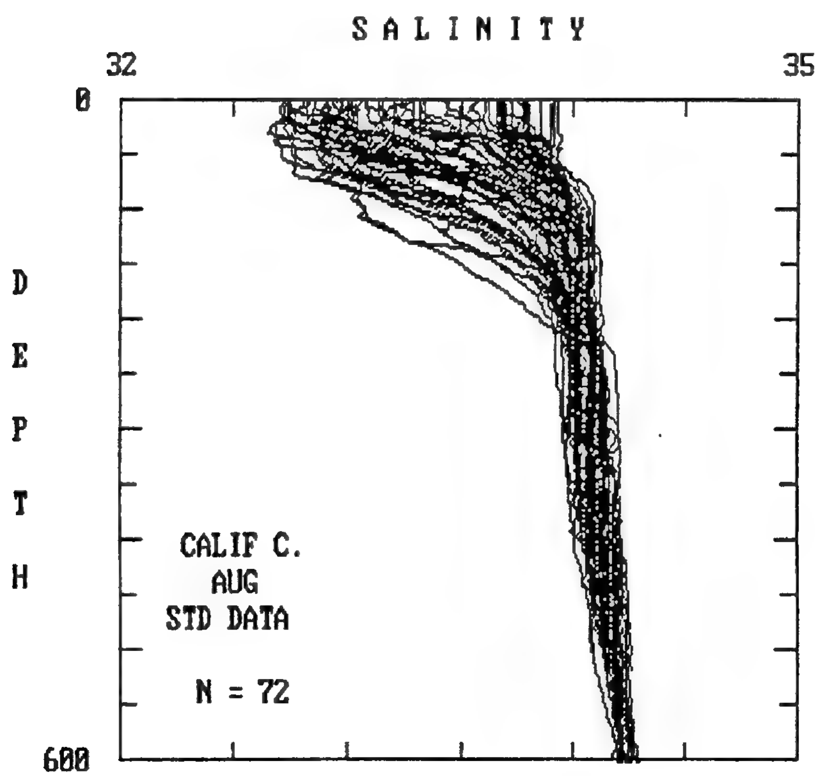


Figure 8. Plot of salinity versus depth.

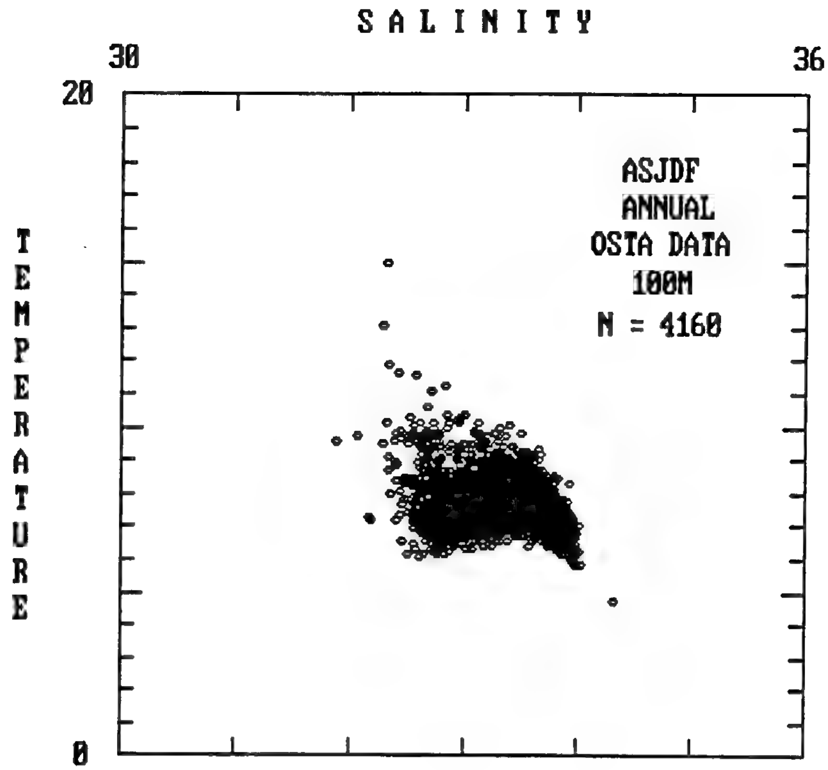


Figure 9. Scatter plot of temperature versus salinity at constant depth.

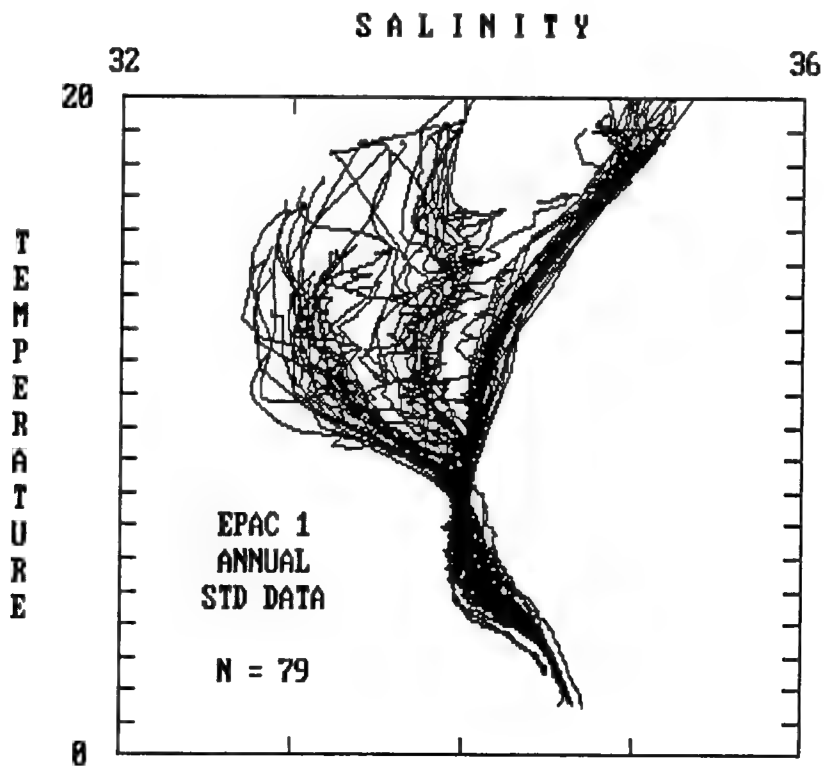


Figure 10. Plot of temperature versus salinity over the full depth spectrum.

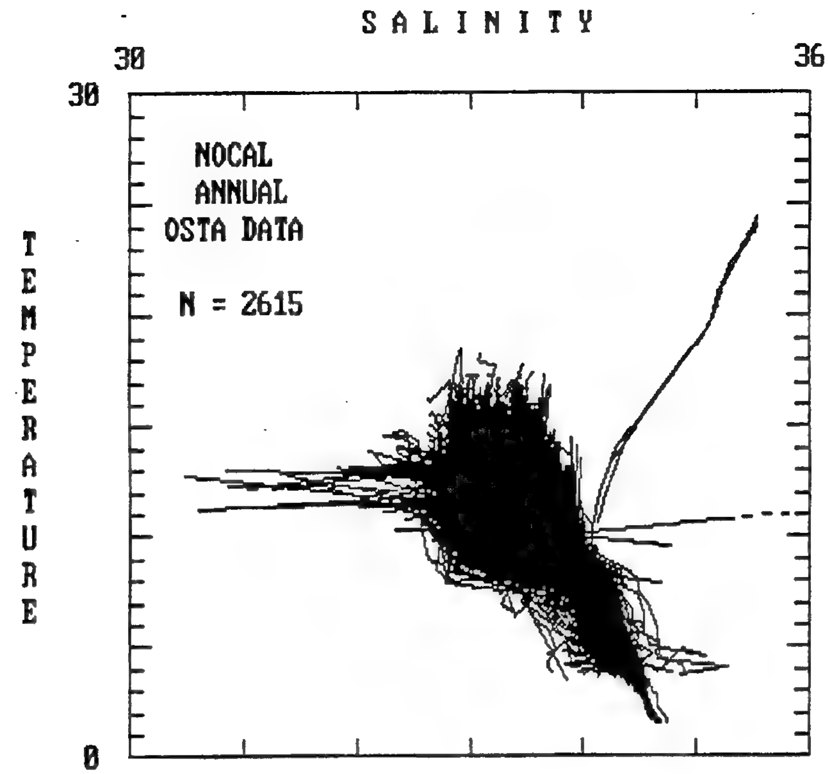


Figure 11. Plot of temperature versus salinity using hydrocast data.

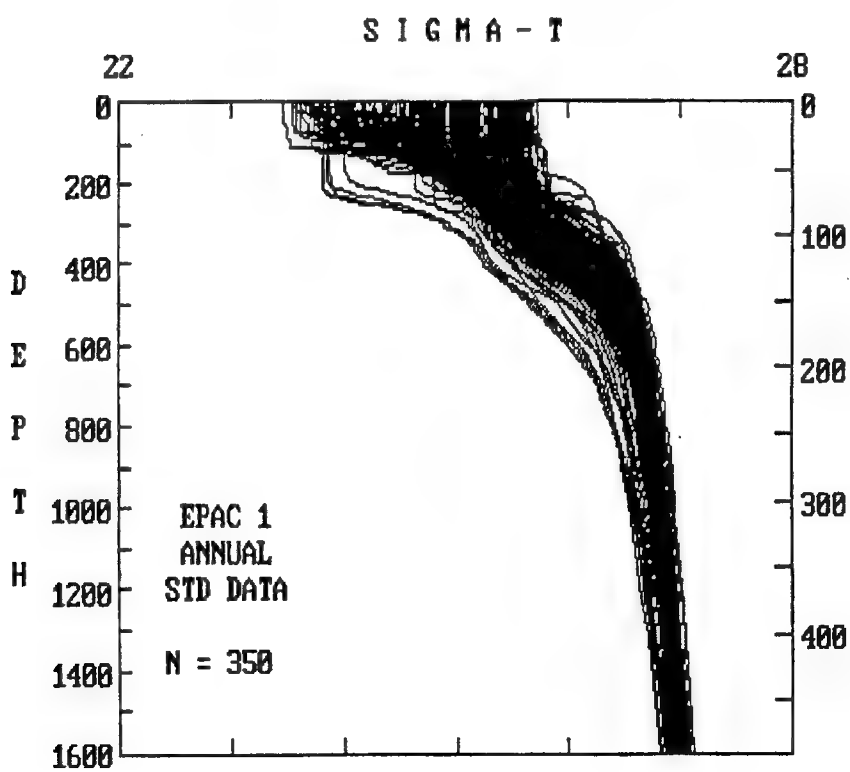


Figure 12. Plot of sigma–t versus depth.

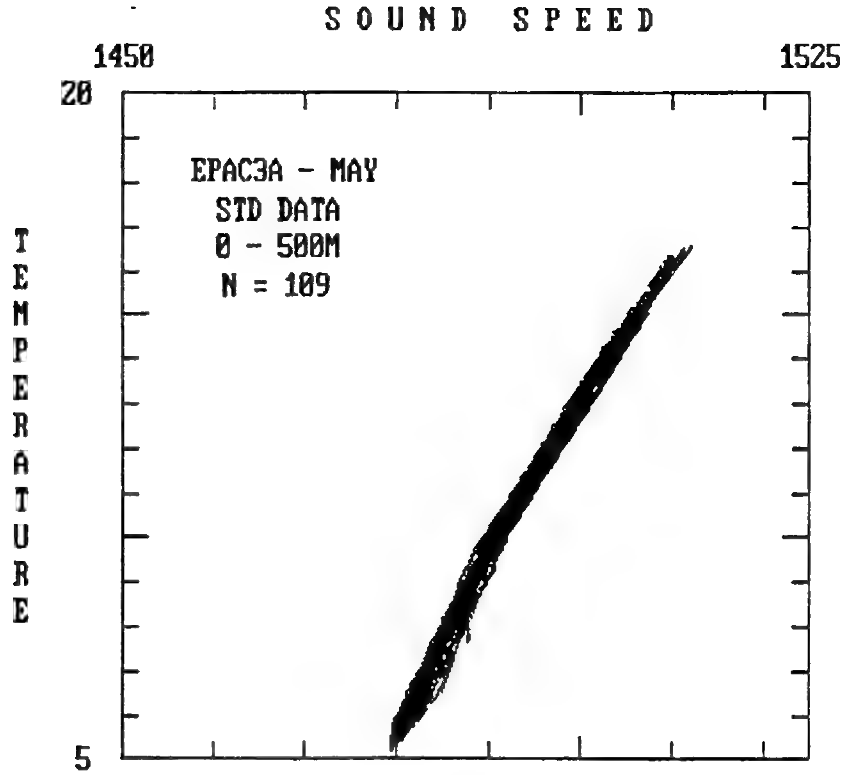


Figure 13. Plot of sound speed versus temperature.

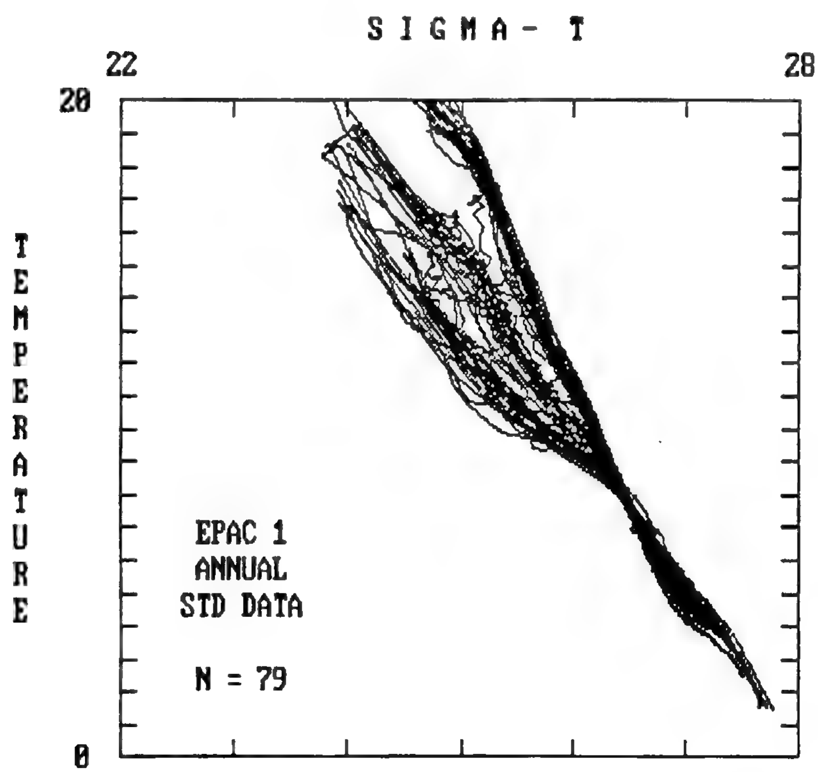


Figure 14. Plot of sigma–t versus temperature.

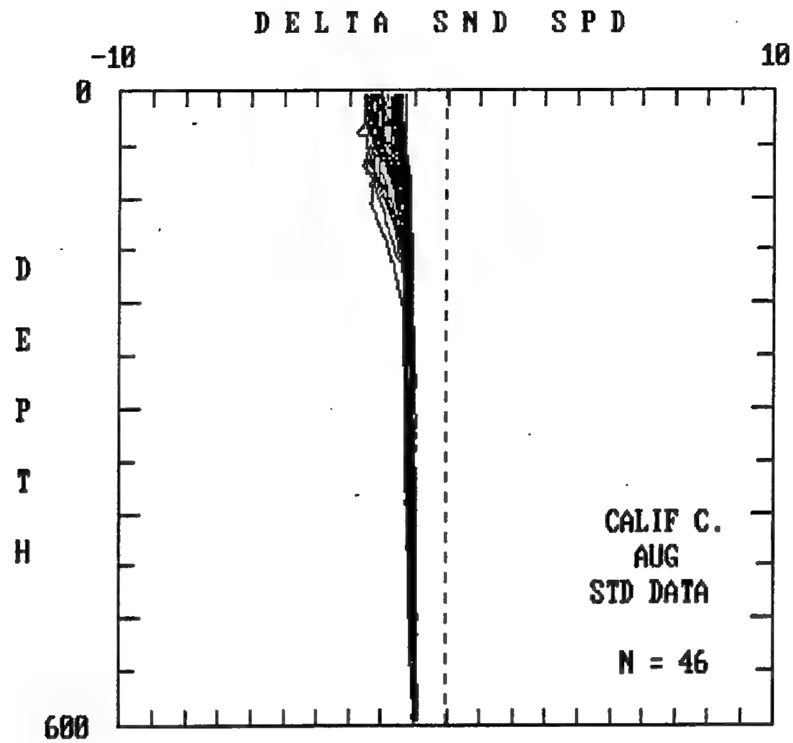


Figure 15. Plot of the salinity contribution to sound speed versus depth for the eastern North Pacific Ocean.

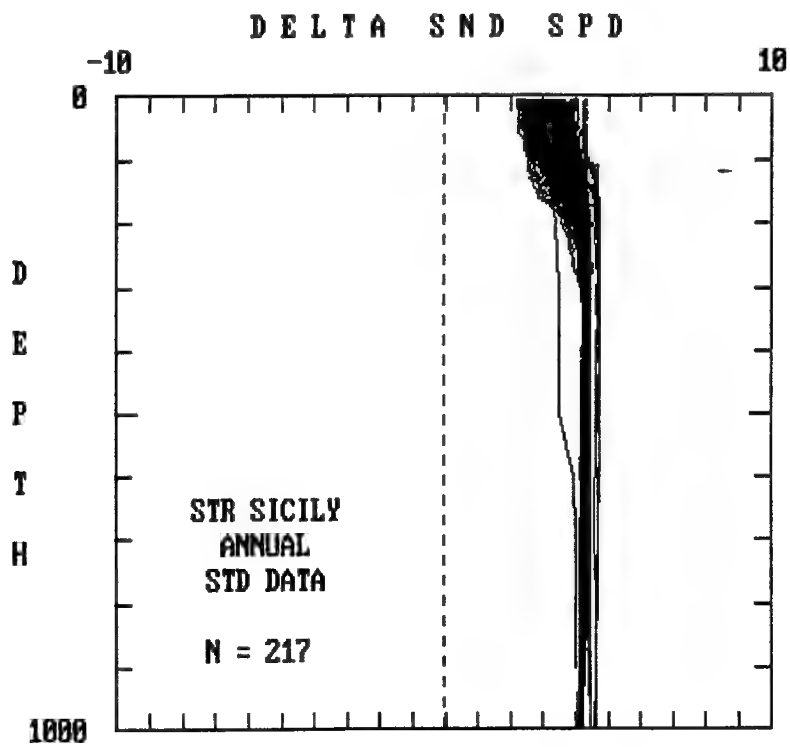
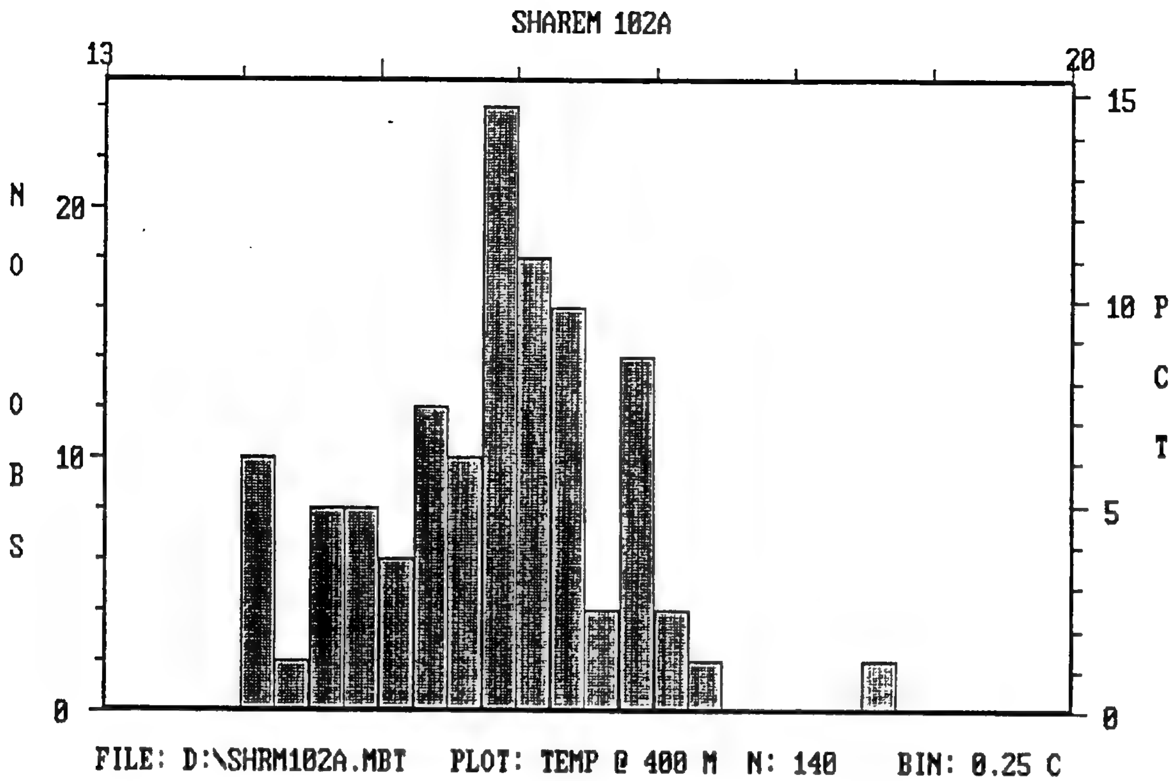


Figure 16. Plot of the salinity contribution to sound speed versus depth in the Mediterranean Sea.



(a)

DATA: SHAREM 102A
SOURCE: MOODS
OBS: 100
MEAN: 24.34

PERIOD: JAN
BIN SIZE: 0.25 C
S.D.: .72

FILE: D:\SHRM102A.MBT
PLOT: SURFACE TEMP
MEDIAN: 24.2
RANGE: 22.6 TO 25.8

BIN	N	BN SIZE	PCT	CUM
1	0	21.00 - 21.24	0.0	0.0
2	0	21.25 - 21.49	0.0	0.0
3	0	21.50 - 21.74	0.0	0.0
4	0	21.75 - 21.99	0.0	0.0
5	0	22.00 - 22.24	0.0	0.0
6	0	22.25 - 22.49	0.0	0.0
7	1	22.50 - 22.74	1.0	1.0
8	0	22.75 - 22.99	0.0	1.0
9	2	23.00 - 23.24	2.0	3.0
10	8	23.25 - 23.49	8.0	11.0
11	16	23.50 - 23.74	16.0	27.0
12	15	23.75 - 23.99	15.0	42.0
13	8	24.00 - 24.24	8.0	50.0
14	4	24.25 - 24.49	4.0	54.0
15	6	24.50 - 24.74	6.0	60.0
16	14	24.75 - 24.99	14.0	74.0
17	16	25.00 - 25.24	16.0	90.0
18	6	25.25 - 25.49	6.0	96.0
19	3	25.50 - 25.74	3.0	99.0
20	1	25.75 - 25.99	1.0	100.0
21	0	26.00 - 26.24	0.0	100.0
22	0	26.25 - 26.49	0.0	100.0
23	0	26.50 - 26.74	0.0	100.0
24	0	26.75 - 26.99	0.0	100.0

(b)

Figure 17. Histogram output: (a) histogram plot of surface temperature; (b) printout of histogram computations.

DATA: CAN NW - MAR
FILE: D:\CANNW.MST SOURCE: MOODS
PERIOD: MAR
TYPE: STD

PARAMETER SUMMARY

	N	MEAN	S.D.	MIN	MAX	DEFINITION
SFC T	102	7.49	1.12	4.66	9.30	
T@25 M	104	7.36	1.08	4.65	9.23	
T50	104	7.26	1.06	4.61	9.53	
T100	104	7.20	0.99	4.56	9.55	
T150	102	6.94	1.03	4.90	8.97	
T200	100	6.43	1.07	4.39	9.13	
T250	100	5.94	0.95	4.06	8.24	
T300	100	5.51	0.83	3.87	7.51	
T400	100	4.85	0.55	3.60	6.66	
SLD	86	107.2	72.0	0.0	240.0	
SFC COF	70	293	465	80	1647	<= 5200 HZ
SC AXIS	69	415.2	136.5	38.0	732.0	
SC THCK	69	857	487	48	1500	=> 10 M THICK
SC COF	69	52	127	2	686	<= 800 HZ
BEST Z	86	186	92	10	433	DPTH MIN GRAD
DV/DZ	86	-0.095	0.046	-0.219	-0.011	=> 10 M THICK
DEL Z	86	-21	70	-95	159	DIF FM LD-100
SFC S	102	32.24	0.28	31.41	32.66	
S@25 M	104	32.32	0.21	31.56	32.66	
S50	104	32.39	0.16	31.91	32.78	
S100	104	32.79	0.40	32.24	33.63	
S150	102	33.45	0.44	32.32	33.87	
S200	100	33.77	0.24	32.64	33.95	
S250	100	33.88	0.08	33.64	34.01	
S300	100	33.93	0.05	33.84	34.03	
S400	100	34.01	0.04	33.94	34.07	

NUMBER USEFUL SOUND CHANNELS: 69 OR 67.6 PCT.
NUMBER ZERO SLD: 9 OR 8.8 PCT.
NUMBER HALF CHANNELS: 16 OR 15.6 PCT.
NUMBER MULT SND CHAN: 43 OR 42.1 PCT.

Figure 18. Statistical printout of temperature, salinity, and acoustic parameters for region CANNW.

DATA: CAN NW - JUN
FILE: D:\CANNW.MST

SOURCE: MOODS

PERIOD: JUN
TYPE: STD DATA

FIRST PARAMETER: SFC T SECOND PARAMETER: SFC S

OBS: 58 COEF: -0.5140

	MEAN	S.D.	MIN	MAX
SFC T :	10.78	0.79	8.37	11.96
SFC S :	32.13	0.20	31.72	32.47

FIRST PARAMETER: SFC T SECOND PARAMETER: S@25 M

OBS: 58 COEF: -0.3280

	MEAN	S.D.	MIN	MAX
SFC T :	10.78	0.79	8.37	11.96
S@25 M :	32.29	0.20	31.97	32.77

FIRST PARAMETER: SFC T SECOND PARAMETER: S50

OBS: 58 COEF: -0.0740

	MEAN	S.D.	MIN	MAX
SFC T :	10.78	0.79	8.37	11.96
S50 :	32.44	0.21	32.02	33.11

FIRST PARAMETER: SFC T SECOND PARAMETER: S100

OBS: 54 COEF: 0.4700

	MEAN	S.D.	MIN	MAX
SFC T :	10.77	0.81	8.37	11.96
S100 :	33.00	0.30	32.46	33.91

FIRST PARAMETER: SFC T SECOND PARAMETER: S150

OBS: 54 COEF: 0.2930

	MEAN	S.D.	MIN	MAX
SFC T :	10.77	0.81	8.37	11.96
S150 :	33.70	0.12	33.42	33.94

Figure 19. Printout of correlation between parameters for region CANNW.

APPENDIX A
TYPICAL RUN STREAM

ARCHIVED DATA

A1. The archived data shown in figures 1 through 5[1] are archived in the Sun SPARC 10 host WAHOO (DDN address 128.49.16.38)[2]. File parameters are:

Directory	Type Data	Extension	No. Files	Blocks
XBT0	C–T–D/S–T–D	.MST	98	125604
XBT2A	XBT	.MBT	109	275430
TSZ	Hydrocast	.MOS	99	72745

You may access these data by using the TERMINAL command from a personal computer (PC) tied into the General Computing Backbone (GCB) at NRaD; use the procedure listed below. Note that you must have a user identifier and password before you can access the system. If you need these keywords, see your department computer security agent.[3]

T2

Program Terminal will connect with the GCB and establish the connection after you enter the following administrative information[4]:

```
LO
#location 8

CA
#call a50⁵

#  CALL COMPLETED TO 0158,1
<return>

login: jdoe

Password: abcdef

Last interactive login on . . . (date, time)

TERM TYPE (VT100)? <return>
```

[1]Figure numbers in this appendix refer to figures in the main text.

[2]The processing and analysis of MOODS data on WAHOO is examined in reference 3 (see main text).

[3]These commands, with instructions, may be obtained from the Computer Resource Center, located in Building A33, Topside.

[4]In this document, information that you type is shown in **boldface**.

[5]Use lower case when entering administrative material into WAHOO.

After successfully logging into WAHOO, open the desired directory from the root directory by entering UNIX commands. For example, directory XBT2A would be accessed by entering the command:

```
SET DEF [.XBT2A]
```

Should you want data not in the current directory, you must first return to the root directory:

```
SET DEF [-]
SET DEF [.new directory]
```

Available files in each directory may be reviewed using the DIR command. For example, if you wanted a listing of XBT data from directory XBT2A, you would enter:

```
DIR *.MBT
```

Note that many more files will be listed than appear on the list of files shown in figures 1 through 5. This list is the result of creating files based on water mass characteristics using data analysis routines resident in WAHOO. For example, a file of XBT data from region EPAC3A containing temperature values between 9°C and 15°C at a depth of 200 m might be listed as EP3A0915.

Files are downloaded one at a time using the microcopy protocol:

```
MCP T <arcdfile.ext> MICRO:<newname.ext>
```

Note that the new file may have either the same name as the archived file or any new name you desire, as long as length of the file name is restricted to eight letters or less.

After all desired files have been downloaded, you exit WAHOO by entering the command:

```
LOGOUT
<f10>
```

Before accessing data from the archival file, any data downloaded from WAHOO must be copied from the root directory (usually the C: drive) by using the MS/DOS COPY command. The wild card (asterisk) can be used as done in normal MS/DOS procedures. For example, XBT (extension .MBT) and hydrocast (.MOS) data from region EPAC3 may be copied from the root directory to the archival directory by entering the COPY command and typing:

```
COPY EPAC3.* d:\*.*
```

The PC archival file is not large enough to hold all the files contained in WAHOO. Therefore, you may have to download a few files at a time, work on those files, delete them by using the MS/DOS "DEL" or "ERASE" command, and then repeat the process until all desired files have been examined.

DRIVE ASSIGNMENTS

A2. Automatic drive assignment is made by using Program MDSDRV. You type **MDSDRV** to start this routine. Note that the backslash and colon (:\) used to denote PC drives are omitted when designating units. They will be added automatically by the program.

```
ENTER THE DRIVE FOR THE STORED MOODS DATA: d
IS DRIVE D: CORRECT?  ANS Y OR N: Y
```
[6]

```
ENTER DRIVE FOR CLASSIFIED OUTPUT: c
IS DRIVE C: CORRECT?  ANS Y OR N: Y
```

Program MDS will henceforth look for archival data on drive D: and store classified material on drive C: until reset by Program MDSDRV. Classified output will be stored in a sequential file with the same name as the data file, but with the extension .MCL. It may be printed on any unclassified system by using the MS/DOS command TYPE:

```
TYPE <filename>
```

where <filename> is the name of the stored file.

MAIN PROGRAM

A3. Start Program MDS by typing:

```
MDS
```

The program will ask if the computer processing the data is secure. If you reply in the affirmative, printer output is not possible, and the material will be stored for later printing.

```
IS THIS PROGRAM BEING RUN ON A SECURE SYSTEM? N
```

You then will be asked to enter information required to initiate the run. Initial items are the name of the desired file and the type of data in the file. Do not enter the file extension as part of the file name; it will be added automatically. A plot title of 12 letters or less may be added if desired. If a title is not desired, press **<return>** when asked for input. You then must indicate the period of the data processed. Note that data plotted for the designated period will include all years to provide a larger statistical database that will show the influence of annual variability. Finally, you must indicate if one of the three analysis functions is to be exercised or the program ended.

```
ENTER FILE NAME (W/O EXTENSION): shrm102a

INDICATE TYPE DATA TO BE PROCESSED:
  (1) XBT DATA              [.MBT]
  (2) CTD/STD DATA          [.MST]
  (3) HYDROCAST DATA        [.MOS]
  (4) AXBT DATA             [.MAX]
  (5) BATHY MESSAGE DATA    [.MSG]
  (6) END PROGRAM
ENTER TYPE DATA: 2
```

---

[6]Verification statements requiring a Y or N response are used throughout the computer dialogue. In the interest of simplicity, these statements will not be used henceforth in this text.

```
ENTER PLOT TITLE (12-LTR MAX): SHAREM 102A

SELECT PERIOD:
  (1) JAN         (7) JUL        (13) WINTER (JAN-MAR)
  (2) FEB         (8) AUG        (14) SPRING (APR-JUN)
  (3) MAR         (9) SEP        (15) SUMMER (JUL-SEP)
  (4) APR        (10) OCT        (16) AUTUMN (OCT-DEC)
  (5) MAY        (11) NOV        (17) ANNUAL (JAN-DEC)
  (6) JUN        (12) DEC
```

ENTER CORRECT PERIOD: **1**

SELECT FUNCTION:
(1) PLOT PARAMETERS
(2) PLOT HISTOGRAM
(3) GENERATE GROUP STATISTICS
(4) END PROGRAM
ENTER DESIRED FUNCTION: **1**

On completion of the setup routine, the program will call the desired routine and continue the setup procedure.

After the output is completed, you will be asked if another run is desired. If the response is affirmative, you have the option either of making additional plots with the same data, or returning to the main program to access another file. If additional runs are not desired, the program will end.

PARAMETER PLOTS

A4. On selection of the plot package, this routine is chained automatically to the main program.

Note: Plots of sound speed and density computed from XBT data may be in error because constant salinity of 35 o/oo is used instead of in-situ salinity. The errors will be magnified where (1) low-salinity water occurs in estuarine and polar regions, (2) high-salinity water occurs in areas of high evaporation in the tropics, and (3) water mass mixing occurs coincident with strong oceanic fronts. Where plots are made using XBT data, Program MDS prints the following caution:

```
DENSITY AND ACOUSTIC PARAMETERS ARE COMPUTED WITH
SALINITY OF 35 o/oo.
```

Note: Salinity observations are frequently less accurate than depth and temperature measurements. Because the laws of physics require that density increase with respect to depth, some oceanographers adjust salinity values to ensure a stable water column. Program MDS does not apply this correction.

```
ENTER TYPE PLOT DESIRED:
    (1) TEMPERATURE VS DEPTH
    (2) SOUND SPEED VS DEPTH
    (3) SALINITY VS DEPTH
    (4) TEMPERATURE VS SALINITY
    (5) SIGMA-T VS DEPTH
    (6) SIGMA-T VS TEMPERATURE
    (7) SOUND SPEED VS TEMPERATURE
    (8) DELTA SV VS TEMPERATURE
    (9) END PROGRAM
ENTER CHOICE: 2
```

If the data source is either XBT or AXBT profiles or BATHY messages, items 3, 4, 6, and 8 are listed as "OPTION NOT AVAILABLE" because the plots would be meaningless when used with constant salinity.

If option 4 is selected, you will be asked if the data should be plotted at a particular depth. If a scatter plot such as that shown in figure 8 is desired, you should answer affirmatively and indicate plot depth. Otherwise, composite plots for the entire depth spectrum will be plotted (figure 7).

The most frequent format for plotting graphics is to print the data on a single plot. Thus, the routine will ask you:

```
MULTIPLE TRACES WILL BE PLOTTED ON THE SAME GRAPHIC.
IS THAT OK? Y
```

If you want to examine each profile separately, then answer in the negative. If your answer is affirmative, you will be asked if the plot should be limited to 500 observations. When a large database is being plotted, additional plots may add little to the graphic while taking too much time. If single plots are plotted, you will be asked after each plot if an additional plot is desired.

Parameter ranges may vary considerably among the observations of a file. Thus, you have the option of selecting plot limits. Depth limits vary according to the type of data being plotted. For example, only a few XBT data will exceed 800 m, and most will be less than 500 m. Thus, a maximum depth selection of 800 m for the graphic is more reasonable than a depth of 1000 m. For parameters other than depth, the minimum and maximum values of the initial profile are given to assist selection of graphic limits. More exact values may be obtained by first running the Group Statistic option in the main menu.

On selection of the required delineators, the program will run automatically until either the data have been exhausted or until a specified number of observations have been plotted. You will then be asked if additional graphics are desired or if the program should be ended.

```
DO YOU WANT TO MAKE ANOTHER RUN?  Y
```

If additional data is desired, answer in the affirmative and the program will ask:

```
ARE DATA FILE AND PERIOD THE SAME? Y
```

An affirmative answer will cause the program to restart immediately. Otherwise, the program will revert to the setup program discussed above.

HISTOGRAMS

A5. The histogram routine is called automatically when this option is selected. The first query asks you to select the type plot required.

```
SELECT TYPE DATA FOR HISTOGRAM:
  (1) TEMPERATURE
  (2) SALINITY
  (3) ACOUSTIC
ENTER TYPE DATA: 1
```

Should you select either option 1 or option 2, you will be asked to select one of nine options. For temperature data, the options appear as:

```
SELECT HISTOGRAM PLOT:
  (1) SURFACE TEMP
  (2) TEMP @ 25 M
  (3) TEMP @ 50 M
  (4) TEMP @ 100 M
  (5) TEMP @ 150 M
  (6) TEMP @ 200 M
  (7) TEMP @ 250 M
  (8) TEMP @ 300 M
  (9) TEMP @ 400 M
ENTER APPROPRIATE NUMBER: 4
```

A nominal salinity of 35 parts per thousand (o/oo) is assigned to XBT, AXBT, and BATHY message data to allow sound speed calculations. If you request salinity histograms for these data, you will be asked to select another option. Where C-S-T/S-T-D or hydrocast data are being posted, you will be asked to select salinity values from a list similar to the temperature list.

If you request acoustic information,[7] you will be asked to select one of the following options:

```
SELECT HISTOGRAM PLOT:
  (1) SONIC LAYER DEPTH
  (2) SFC CUT-OFF FREQ
  (3) SND CHAN AXIAL DEPTH
  (4) SND CHAN THICKNESS
  (5) SND CHAN CUT-OFF FREQ
ENTER APPROPRIATE NUMBER: 2
```

---

[7]Acoustic parameter definitions are given in appendix B.

The program will examine the raw data and show the minimum and maximum values detected. These values are rounded up or down by one unit to produce a graphic that is easier to read. This is useful when temperature is plotted (e.g., 13°C to 21°C), but of little use where layer depth or axial depth are plotted (4 to 253 m). In the latter case, a more pleasing plot will be achieved by changing the minimum and maximum plot values to 0 and 300, respectively.

You will then be asked to indicate bin size. Bin size normally is determined by the range of values and accuracy of the parameter being plotted. For example, bin sizes of 0.10 or 0.25 are appropriate for temperature plots having a range of 10 degrees, but bin size of 2 m for a layer depth plot from XBT data with a range of 150 m is meaningless as it is outside the accuracy of the instrument.

```
SELECT BIN SIZE:
  (1) 0.10                        (6)    5
  (2) 0.25                        (7)   10
  (3) 0.50                        (8)   25
  (4) 1.00                        (9)   50
  (5) 2.00                       (10)  100
ENTER BIN SIZE: 9
```

If bin size exceeds 100, you will be asked to either (1) decrease the plot limits or (2) increase bin size.

The desired graphics are then plotted, as shown in figure 17a. The information can also be provided in tabular form, as shown in figure 17b. If using a secure system, the tables will be stored on the designated drive for printing elsewhere. You will then be asked if additional graphics are desired or if the program should be ended as discussed in paragraph A4.

STATISTICAL DATA

A6. Statistical routines are accessed automatically when designated at the main menu. You must indicate how the data should be processed and, if you select the correlation option, what parameters are to be examined:

```
INDICATE TYPE OUTPUT:
  (1) GROUP STATISTICS ONLY
  (2) CORRELATION BETWEEN GROUPS ONLY
  (3) CORRELATION AND STATS
ENTER CHOICE: 3
```

The statistical option examines all parameters for which data are available. However, you must designate which parameters are to be correlated, with reiteration until no further computations are desired. Two parameters must be selected using the following menus:

```
SELECT INITIAL PARAMETER:
  (1) TEMPERATURE (SINGLE DEPTH)
  (2) SALINITY (SINGLE DEPTH)
  (3) SONIC LAYER DEPTH
  (4) SOUND CHANNEL AXIAL DEPTH
```

```
   (5) SOUND CHANNEL THICKNESS
   (6) CUT-OFF FREQUENCY IN SOUND CHANNEL
   (7) DEPTH OF MINIMUM GRADIENT
   (8) MINIMUM SND SPD GRADIENT
ENTER SELECTION: 1

SELECT DEPTH
   (1) SEA SFC        (4) 100 M        (7) 250 M
   (2) 25 M           (5) 150 M        (8) 300 M
   (3) 50 M           (6) 200 M        (9) 400 M
ENTER CHOICE: 1

SELECT SECOND PARAMETER:
   (1) TEMPERATURE (STANDARD DEPTHS)
   (2) SALINITY (STANDARD DEPTHS)
   (3) SONIC LAYER DEPTH
   (4) SOUND CHANNEL AXIAL DEPTH
   (5) SOUND CHANNEL THICKNESS
   (6) CUT-OFF FREQUENCY IN SOUND CHANNEL
   (7) DEPTH OF MINIMUM GRADIENT
   (8) MINIMUM SND SPD GRADIENT
ENTER SELECTION: 3
```

The standard depths examined are those listed above in the depth menu.

After completing the specified option, you may either recycle or end the program.

```
DO YOU WANT TO MAKE ANOTHER RUN?  Y
```

If your answer is negative, the program will end. If your answer is affirmative, Progam MDS will repeat the setup procedure. Whenever a negative response is made, the program will revert to the setup procedure described in paragraph A3.

```
DO YOU WANT TO START PROGRAM 'MDS' FROM THE BEGINNING?
N

IS THE FILE NAME STILL CANNW? Y

ARE THE DATA STILL STD? Y

IS THE TITLE STILL CAN NW - DEC? Y

IS THE PERIOD STILL NOV?  Y

DO YOU WANT THE STATS OPTION? Y
```

If all your answers were affirmative, as shown above, output would be identical to the previous run.

APPENDIX B

OCEANIC DEFINITIONS

Best Depth: The best depth for a submarine to avoid detection by a hull-mounted sonar. This assumption is based on the premise that maximum downward refraction of sonic energy will occur at the depth of the strongest minimum sound speed gradient, thus causing short horizontal sonar ranges. In this report, the depth stratum containing the gradient must have a thickness of 10 m or more. This definition disagrees with the adage that defines the best depth to avoid detection as sonic layer depth plus 100 m.

Cut-off Frequency (COF): The minimum frequency, in hertz, that will remain entrapped within a sound channel. Also called *low-frequency cut-off.* For the surface layer, COF is defined as:

$$Fo = 0.3978 * V_o^{1.5} / (SLD * (V_{sld} - V_o))^{0.5}$$

where V_o and V_{sld} are sound speed at the surface and sonic layer depth, respectively. Not computed for near-surface layers less than 10 m thick; ignored for frequencies greater than 5.2 kHz.

Cut-off frequency for sound channels below the surface duct is calculated by using:

$$Fc = 0.2652*V_a^{1.5} / (\Delta Z * (V_b - V_a))^{0.5}$$

where ΔZ is sound channel thickness and V_a and V_b are sound speed at the sound channel axis and the sound channel boundaries, respectively. Not computed for sound channels less than 10 m thick.

Deep Sound Channel: A subsurface duct for long-range transmission of acoustic signals. *Axial depth* of the channel is the depth of minimum sound speed between the sea surface and the ocean floor. Also called the *primary sound channel.*

Half Channel: The special case where the sound speed profile exhibits a minimum at the sea surface and a maximum at the sea floor. By definition, neither sonic layer nor sound channels may occur in a half channel. Normally a winter phenomenon associated with polar regions and the Mediterranean Sea.

Near-surface Layer: The layer extending from the sea surface to sonic layer depth.

Secondary Sound Channel: A sound channel located between sonic layer depth and the axial depth of the deep sound channel. Also called a *near-surface sound channel* to distinguish it from the deep sound channel. *Channel thickness* is the depth interval between the sound speed maxima denoting the top and bottom of the sound channel. More than one, or *multiple channels*, may occur on the same profile.

Sigma-T: An abbreviated form of density:

$$\sigma_t = 1000 * (\rho - 1.0)$$

where ρ is density. For example, sigma-t of 28.5 equates to a density of 1.0285 gms/cm$_3$.

Sonic Layer Depth (SLD): The depth of maximum sound speed above the deep sound channel axis.

Surface Channel: An acoustic duct between the sea surface and the sonic layer depth.

Useful Sound Channel: A secondary sound channel with a cut-off frequency of less than 800 Hz.

Zero Layer Depth: The special case where sonic layer depth occurs at the surface. Occurs most frequently in tropical and subtropical regions where surface winds are insufficient to cause mixing.

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Program MDS uses an IBM-compatible personal computer to process and analyze temperature, salinity, and sound speed data in three formats: (1) two-dimensional plots, (2) histograms, and (3) statistical computation and/or correlations. The data, extracted from the MOODS files maintained by the Naval Oceanographic Office, require prior reformatting to regional files for meaningful analysis. Graphic and printer output of these analyses provides valuable input needed to determine oceanic and acoustic properties of a desired area.

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Alvan Fisher, Jr.	(619) 553–1776	Code 742

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